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ORIGINAL ARTICLE

High Association of Posterior Malleolus Fractures with Spiral Distal Tibial Fractures

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Abstract Associations between fracture patterns are important and can ensure proper diagnosis and guide treatment. Occult posterior malleolus fractures associated with distal spiral tibia fractures often are underrecognized and the morbidity of a missed posterior malleolus injury can be substantial. We determined the association between the two injuries and evaluated the ability of a new protocol to improve management of these associated fractures. Of 62 consecutive patients with fractures of the distal third of the tibia, we retrospectively evaluated the first 39 patients and prospectively used a diagnostic protocol including computed tomography of the ankle in the subsequent 23 patients. The minimum followup was 3 months (mean, 25 months; range, 3–68 months). Twenty-four patients (39%) had fractures of the posterior malleolus. Before initiation of the protocol, intraarticular fractures were recognized in 33% (with one delayed diagnosis and one missed diagnosis), and after institution of the protocol, the detection rate was 48% with no known missed injuries and complete followup; however, with the limited power the detection rates were similar without and with the protocol. A spiral distal tibial shaft fracture with a proximal fibula fracture should alert the surgeon to investigate an occult ankle injury, particularly of the posterior malleolus. A protocol including computed tomography of the ankle may detect more injuries in a larger study.
Level of Evidence: Level II, prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has waived or does not require informed consent from the patients given the retrospective nature of this study.

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Introduction

The combination of a tibial shaft fracture and posterior malleolus fracture is a well-known entity that can have a substantial impact on treatment approaches. The association between the two injuries, however, remains unclear. Bostman reported a 0.6% incidence of concurrent ankle fractures with tibial fractures [2, 3]. Van der Werken and Zeegers, however, reported a rate of 11.5% [18]. A more recent study reported a higher incidence of 25% [11]. Most likely, the variably reported rates are secondary to increased detection with improved imaging quality and increased awareness of the association.

Unrecognized posterior malleolus fractures may displace during reduction maneuvers or with intramedullary reaming or nailing [6] and during the postoperative period as a result of aggressive range of motion exercises of the ankle and early weightbearing. Although various treatment options have been described, two studies advocated internal fixation when associated with tibial shaft and ipsilateral ankle fractures [10, 14]. Early knee and ankle mobilization is crucial to prevent postsurgical stiffness, and thus stable

fixation of the posterior malleolus is particularly important in combined injuries.

Given the controversy in the literature on the incidence of associated posterior malleolus fractures, we first determined the incidence of posterior malleolus fractures and second evaluated the efficacy of a diagnostic protocol designed to improve detection and treatment of these associated injuries.

Materials and Methods

We identified 114 consecutive patients with a tibial diaphyseal shaft fracture between March 2002 and August 2007. Of these, 62 had fractures of the distal third of the diaphysis and formed the study cohort. The mean age of the patients at presentation was 45 years (range, 18–76 years) and 42 patients were men. Thirty-seven patients had spiral tibial fractures (42A-1) (61.2%), 12 had oblique fractures (42A-2) (19%), and three had transverse fractures (42A-3) (4.8%). Ten fractures (16.12%) were comminuted. Thirteen injuries were the result of high-velocity mechanisms, eight of which were motor vehicle accidents and five were from a fall from a height. No patients were lost to followup. The minimum followup was 3 months (mean, 25 months; range, 3–68 months). We judged the 3-month minimum an appropriate interval to subsequently detect a clinically relevant ankle fracture if it had not been previously identified. The Institutional Review Board approved the study protocol.

Because we encountered one patient with a delayed diagnosis and one with a missed injury, we instituted a protocol in June 2006 to better identify injuries. This protocol included preoperative anteroposterior and lateral radiographs of the tibia and ankle and a fine-cut (2 mm) computed tomographic (CT) scan of the ankle for all distal third tibial diaphyseal fractures. We treated 23 patients after initiation of the protocol and these patients formed the cohort of the prospective arm. Data collection before the institution of the protocol was retrospective and included 39 patients. In the retrospective arm, of 39 patients, 10 patients underwent CT scanning to evaluate the fracture and the ankle. This was based on the clinician's perception of requirement of a CT scan rather than any protocol. All recognized associated posterior malleolus fractures were stabilized operatively.

We (SB, DGL) retrospectively reviewed all the radiographs. The dimensions of the posterior malleolus fragments were measured on the CT scan. We used the axial section just above the plafond to measure the maximum length and maximum breadth of the fragment (Fig. 1). A sagittal section was used to measure the height.

To determine if there was a difference in the number of missed injuries between the two groups, we performed a Fisher's exact test. Fisher's exact test also was performed to compare the incidence of detected posterior malleolus fractures before and after institution of the protocol. Because CT scanning was performed on 10 patients in the retrospective group based on the clinical indications, we performed Fisher's exact test to determine the sensitivity of CT scans and plain radiographs to detect the associated posterior malleolus injury.

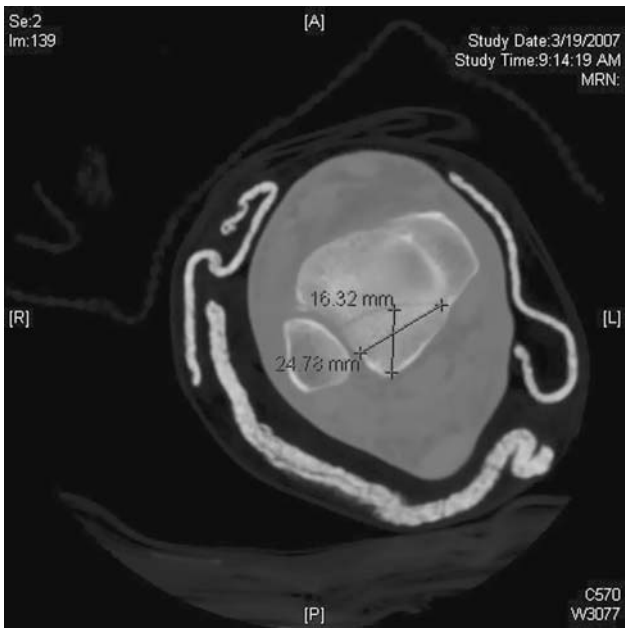

Fig. 1 An axial section of the CT scan shows the measurements of the posterior malleolus fracture fragment.

Results

Twenty-four of the 62 patients with distal tibial fracture (39%) had an associated posterior malleolus fracture. Of the 24 patients with posterior malleolus fractures, 22 had associated spiral fractures of the tibia and in none were the fracture lines contiguous with the diaphyseal fracture lines. Twenty of these patients (95%) also had a fibular fracture proximal to the level of the tibia fracture, also indicating a low-energy rotational mechanism (Fig. 2). In two patients, a posterior malleolus fracture occurred with a comminuted distal tibial diaphysis, and in these patients, an occult fracture line extended into the posterior tibial lip. Of the 37 spiral fracture patterns, 21 (56%) had a concomitant posterior malleolus fracture. Additionally, two patients had a medial malleolus fracture. One patient had a Tillaux-Chaput fracture anteriorly. After institution of the protocol, there was no delay in diagnosis of the associated injuries and no injuries were missed. We did not identify six posterior malleolus fractures (24%) on plain radiographs, but they were seen on CT scans (Figs. 3, 4). The average length and

Fig. 2A–B (**A**) Anteroposterior and (**B**) lateral radiographs show the typical injury pattern with a spiral distal tibial fracture, proximal fibula fracture, and a posterior malleolus fracture.

breadth of the posterior malleolus fragments measured on the CT scans were 11.4 mm (range, 7.2–28.1 mm) and 14.6 mm (range, 12–34.1 mm), respectively. The average height was 39 mm (range, 14–52 mm) as measured on sagittal section of the CT scan.

Of the 39 patients in the retrospective arm, an associated posterior malleolus fracture was diagnosed in 13 patients (33%), and of the 23 patients in the prospective arm, 11 posterior malleolus fractures (48%) were diagnosed. We failed to detect two of 39 (5%) injuries before the protocol (Table 1), but no posterior malleolus fractures were missed after institution of the protocol. One of the two patients had a delayed diagnosis, and the posterior malleolus fracture was detected only intraoperatively. We did not detect the injury in the other patient. This patient underwent intramedullary nailing and at the 2-month followup at another institution, a displaced posterior malleolus fracture was detected. By report, this patient subsequently underwent revision of fixation with stabilization of the posterior malleolus (Fig. 5). We did not obtain CT scans on either of these two patients.

We observed no difference ($p = 0.532$) in the number of missed injuries between the groups. Also, the detection rate of associated posterior malleolus fractures, before and after institution of the protocol, was similar ($p = 0.471$). The CT scans were more sensitive ($p = 0.04$) than the plain film radiographs in detecting associated posterior malleolus injuries.

Discussion

The association of posterior malleolus fracture with distal spiral tibial fracture often is not recognized. Knowledge of the association may be important not only for optimal stabilization of the fracture, but also for predicating an active postoperative physical therapy regimen. The clinical importance of these associated injuries is not completely known. Our study was designed to examine the incidence of this association and evaluate the efficacy of a specific diagnostic protocol in detecting associated posterior malleolus fractures.

There are several limitations to our study. Aside from the relatively small size of the cohort, particularly in the prospective arm of the study, there is heterogeneity in the demographics and the fracture pattern. The mechanism of injuries also is different. However, 20 of the 24 posterior malleolus fractures were associated with a low-energy twisting mechanism. Sixty-two patients formed the cohort of this study. By including only distal third shaft fractures of the tibia, we had small numbers resulting in an underpowered study to ascertain differences in detection rates. The incidence rates increased from 33% to 49%, yet there were only two missed injuries, both without use of the protocol. All initially unrecognized injuries may not ultimately reveal themselves or displace enough to be detected. This raises a question of the clinical importance of these injuries although our study was not designed to address that question. A prospective, randomized trial after controlling variables like fracture pattern, size of the posterior malleolus fragments, and postoperative physical therapy regimen, is needed before ascertaining the clinical importance of these injuries. Long-term functional outcome analysis is needed to document the final success of any intervention.

The functional outcome after an ankle fracture involving a posterior malleolus fracture is often not satisfactory and may result in considerable osteoarthritis [9, 15]. Indications

Fig. 3A–C (**A**) The posterior malleolus fracture is not seen on these (**A**) anteroposterior and (**B**) lateral radiographs of the tibia and fibula. (**C**) A CT scan shows the posterior malleolus fragment that was not seen on the plain radiographs.

for fixation of the posterior malleolus often are based on the size of the fragment [13, 15]. However, when associated with a tibial shaft fracture, there are no studies describing the outcomes of these fractures managed operatively or nonoperatively. Because of variation in morphologic features of posterior malleolus fractures, using CT may be justified [8]. Distal and presumed extraarticular tibial fractures are treated routinely by intramedullary nailing to reduce and stabilize the metaphyseal fracture. However, in patients in whom a fracture independent of the metaphyseal fracture is present, the size and extent of the intraarticular component of the fracture may be critical in obtaining stability of the ankle and the metaphyseal fracture. In one patient in this series, a previously unrecognized posterior malleolus fracture subsequently displaced. After intramedullary nailing, the initial therapy was based on the tibial shaft fracture alone. She initially was allowed partial weightbearing with aggressive active and passive range of motion exercises for the ankle. Knowledge of the associated posterior malleolus fracture in this patient would have led to concurrent stabilization of this fracture and alteration of the postoperative physical therapy regimen. Fully characterizing the injury thus may be critical for planning treatment.

Fig. 4A–C (**A**) The posterior malleolus fracture is not observed on this anteroposterior radiograph of the tibia and fibula in which the posterior malleolus fracture. (**B**) A lateral view of the tibia and fibula is shown. (**C**) A CT scan shows the posterior malleolus fragment that was not seen on the plain radiographs.

Table 1. Incidence rates and comparison of fractures before and after protocol

Parameter	Preprotocol	Postprotocol
Patients with lower third shaft fractures	39	23
Associated posterior malleolus fractures	13 (33%)	11 (48%)
Spiral fractures	19 (49%)	16 (70%)
Low-energy injuries	22 (56%)	16 (70%)
Delayed/missed diagnosis of associated posterior malleolus fracture	2 (5%)	0

Distal spiral tibial fractures account for approximately one-third of all tibial diaphyseal fractures [17]. In the lower leg, rotational force typically is applied to cause this fracture pattern, and as a result of the osseous anatomy of the tibia, the infraisthmal region at the junction of the middle and distal thirds is prone to fracture [1, 2, 5]. Considering the mechanism of injury, the configuration of the tibial shaft fracture corresponds well to external rotation injuries described by Ender [5]. When the ankle component is involved, it frequently corresponds to a supination-external rotation-type injury [3]. The occurrence of these combined injures was recognized by Lauge-Hansen, who observed several cases of this combined pattern and placed them in the "genetic" classification of ankle fractures [12]. Low-velocity rotational injuries are closely associated with spiral tibial shaft fractures and are strongly associated with posterior malleolus and proximal fibular fractures [16].

Robinson et al. reported 63 patients with distal tibial metaphyseal fractures associated ankle injuries, 13 of whom had posterior malleolus fractures [16]. Preoperatively recognized displaced posterior malleolar fracture underwent open reduction and screw fixation [16]. However, none of their nondisplaced posterior malleolar fractures became displaced after nailing. In another study, 66% of nondisplaced fragments were not internally fixed, and they reported no subsequent problems in these patients

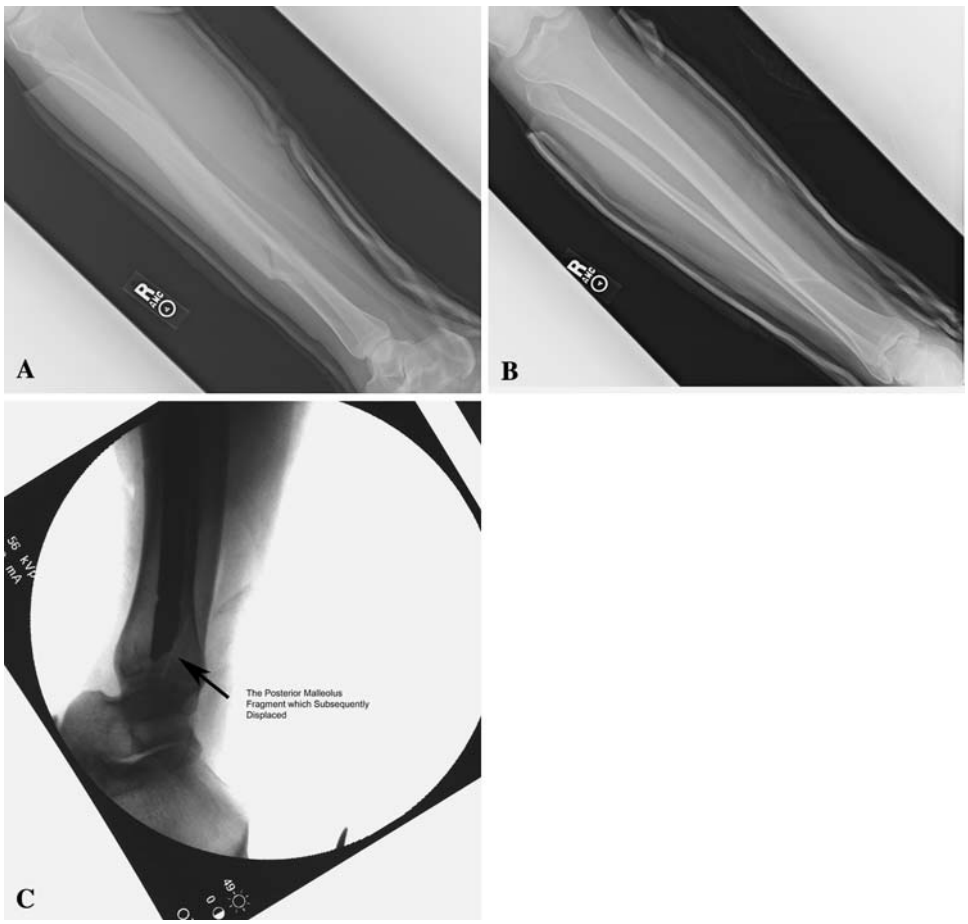

Fig. 5A–C (**A**) Lateral and (**B**) anteroposterior radiographs show the ankle with an occult posterior malleolus fracture, which was missed. (**C**) An intraoperative lateral radiograph shows the fracture of the posterior malleolus.

Table 2. Comparison of studies of associated posterior malleolus injury

Study	Tibial fracture	Method of detection	Number of associated posterior malleolus fractures	Percentage of associated fractures with distal tibia fractures	Surgical intervention
Current study Plain radiographs detection	39 distal tibial fractures	Plain radiograph	13	33%	Surgical fixation when recognized
CT scan detection	23 distal tibia fractures	CT scan	11	47.8%	Surgical fixation when recognized
Kukkonen et al. [11]	74 tibia fractures, 61 distal tibia	*Plain radiograph	18	29.5%	66% underwent surgical fixation
Robinson et al. [16]	63 distal tibial fractures	Plain radiograph	13	†	Surgical fixation only when displaced
van der Werken and Zeegers [18]	148 lower tibia fractures	£Plain radiograph	17	11.5%	Surgical fixation only when displaced

* 10 associated posterior malleolus fractures were not reported but were detected when a retrospective review was conducted; †percentage is not calculated as the study cohort includes distal tibia fractures with associated ankle injuries; £4 were detected intraoperatively and 4 were detected when retrospective review was conducted.

[11]. Georgiadis et al. conversely reported four patients in their series had intraoperative displacement of the posterior malleolus, all of which were unrecognized preoperatively [6] (Table 2). We internally fixed all 24 recognized posterior malleolus fractures whether displaced or not. Treatment consisted of achieving anatomic reduction of the posterior malleolus followed by interfragmentary screw fixation perpendicular or near perpendicular to the fracture line. We typically fixed the fractures from anterior to posterior although in two patients posterior to anterior,

because open reduction was performed in these patients. Fixation was performed most frequently before intramedullary nailing, taking care to place the screws out of the path of the nail.

Nonoperative management has been recommended for treatment of spiral tibial shaft fractures and associated ankle fractures [7, 17]. The current treatment recommendations are predominantly operative [4, 10, 13, 14]. This makes preoperative diagnosis of the associated posterior malleolus fracture imperative. No data are available showing the long-term functional outcomes of tibial fractures with associated nondisplaced posterior malleolus fracture treated operatively or nonoperatively. Based on our experience and that of others, however, the potential for late displacement of the posterior malleolus warrants early detection and stabilization of these injuries. In a study which reported on open and closed diaphyseal fractures with distal intraarticular fracture extension and displacement less than 5 mm, the authors recommend limited open reduction and internal fixation or percutaneous lag screw fixation of the articular component followed by intramedullary nailing [10].

We observed a high incidence of posterior malleolus fractures with spiral distal tibial fractures. The specific injury pattern of a spiral distal third tibial shaft fracture and a fibular fracture at a more proximal level should alert the surgeon to investigate the ankle for an occult fracture. A diagnostic protocol, which includes dedicated ankle radiographs and CT scanning, seems to help detect associated posterior malleolus fractures.

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